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ADSORBENT BODY AND PROCESS FOR PRODUCTION OF SAME

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Abstract

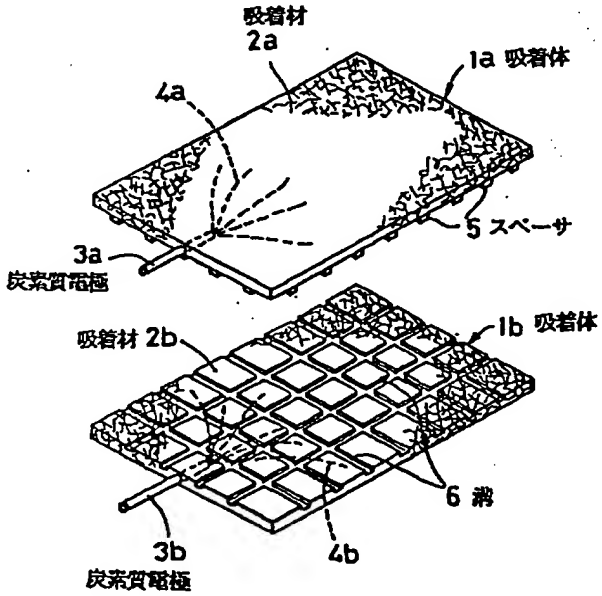
Objective

To impart germicidal action to adsorptive material along with reducing pressure drop and enhancing adsorptive capacity.

Constitution

An adsorbent body (1a, 1b) is composed of pieces of sheet adsorptive material (2a, 2b) made up of sintered bodies of activated carbon, and of carbon electrodes (3a, 3b) integrated with the adsorptive material (2a,2b). Flow channels have been formed between the above-mentioned pieces of adsorptive material using spacers (5) and grooves (6). The above-mentioned adsorbent

body (1a, 1b) is obtained in a process in which a mixture of activated carbon, such as activated carbon fiber, with a fibrous or another sinterable binder is heated under pressure and formed, and carbon electrodes, such as a carbon-fiber yarn, are molded and sintered together with the above-mentioned mixture. The density of the adsorptive material composed of the sintered sheets is 0.4-1.0 g/cm^3 and its thickness is about 0.05-5 mm.



Key: 1a Adsorbent body
1b Adsorbent body
2a Piece of adsorptive material
2b Piece of adsorptive material
3a Carbon electrode
3b Carbon electrode
5 Spacers
6 Grooves

Claims

1. An adsorbent body composed of pieces of adsorptive material made up of sintered bodies of activated carbon and carbon electrodes integrated with the adsorptive material.

2. The adsorbent body according to Claim 1, in which the density of the adsorptive material is 0.4-1.0 g/cm^2.

3. The adsorbent body according to Claim 1, in which the adsorptive material is composed of sintered sheets with a thickness of 0.05-5 mm.

4. The adsorbent body according to Claim 1, in which the activated carbon includes activated carbon fiber and the carbon electrodes include carbon fiber.

5. A process for the production of an adsorbent body, which is a process comprising a press-forming step, wherein at least activated carbon is subjected to press forming, and a sintering step, wherein the resultant formed article is sintered, with a part of the carbon electrodes molded together with the activated carbon.

6. The process for the production of an adsorbent body according to Claim 5, which is a process comprising a forming step, wherein a slurry containing activated carbon fiber and a binder is formed by suction forming or papermaking techniques, and in which in the above-mentioned forming step is carried out by suction forming or papermaking techniques together with a part of the carbon-fiber yarn, and the molded adsorptive material is subjected to pressurization and sintering.

Detailed explanation of the invention

[0001]

Industrial application field

The present invention is concerned with an adsorbent body of high adsorptive capacity capable of electrochemically exterminating germs and with a process for the production thereof.

[0002]

Prior art and problems to be solved by the invention

In Japanese Kokai Utility Model No. Hei 3[1991]-26394, the authors of the present invention have offered an electrochemical germicidal apparatus in which electrodes are formed out of water-permeable adsorbent material containing activated carbon fiber for use as equipment for water purification with electrochemical germicidal effects. In this apparatus, *E. coli* and other microorganisms contained in water from public water supply can be exterminated as the water passes through the above-mentioned water-permeable adsorptive material, while the chlorine component and such can be adsorbed and removed by the water-permeable adsorptive material.

[0003]

However, the above-mentioned adsorptive material contains, for instance, not less than 25% other fibrous materials and heat-meltable resins and other binders, and the packing density of the activated carbon fiber is only 0.1 g/cm^3 or lower. Also, the heat-meltable binder clogs up the pores of the activated carbon, reducing the amount of pores effective for adsorption. For this reason, adsorption per unit volume is low. Also, because it contains other fibrous materials and binders, its electrical resistance is high. Furthermore, the resistance to the passage of the water from public water supply, which passes through the adsorptive material, is high. For this reason, the pressure drop increases, impeding smooth treatment.

[0004]

In addition, attaching metal electrodes to water-permeable adsorptive material including activated carbon fibers and activated carbons has also been considered. In such a case, however, a potential is generated between the carbon and the metal, corroding the metal electrodes. For this reason, the germicidal effects cannot be maintained for an extended period of time.

[0005]

Therefore, it is an object of the present invention to provide an adsorbent body that not only has small pressure drop,

but also has high adsorption per unit volume and is imparted with a germicidal action.

[0006]

It is another object of the present invention to provide a process for the production of an adsorbent body possessing the above-mentioned superior characteristics.

[0007]

Constitution of the invention

The authors of the present invention, as a result of in-depth investigations, completed the present invention by discovering that adsorptive materials obtained at least by compression molding and sintering activated carbon are superior in electrical current-carrying properties and adsorptive capacity, and that pressure drop can be conspicuously reduced by forming flow channels between pieces of adsorptive material made up of sintered bodies.

[0008]

Namely, the present invention provides an adsorbent body composed of pieces of adsorptive material made up of sintered bodies of activated carbon and carbon electrodes integrated with the adsorptive material.

[0009]

It is preferable that the density of the above-mentioned adsorptive material should be 0.4-1.0 g/cm^3, and it is preferable that the adsorptive material should be composed of sintered sheets with a thickness of 0.05-5 mm. Furthermore, it is preferable that the activated carbon should include activated carbon fiber and the carbon electrodes should include carbon fiber.

[0010]

The present invention provides a process for the production of an adsorbent body, which is a process comprising at least a press-forming step, wherein activated carbon is subjected to press forming, and a sintering step, wherein the resultant formed article is sintered, with a part of the carbon electrodes molded together with the activated carbon.

[0011]

This process is a process comprising a forming step, wherein a slurry containing activated carbon fiber and a binder is molded by suction forming or papermaking techniques, and it is preferable that in the above-mentioned forming step, forming should be carried out by suction forming or papermaking techniques together with a part of the carbon-fiber yarn, and the molded adsorptive material should be subjected to pressure and sintering.

[0012]

The present invention is explained in detail herein below by referring to the attached drawings as needed.

[0013]

Figure 1 is an exploded oblique view showing an adsorbent body which represents an application example of the present invention.

[0014]

The above-mentioned adsorbent body (1a, 1b) is composed of pieces of sheet adsorptive material (2a, 2b) made up of sintered sheets of activated carbon, and of carbon electrodes (3a, 3b) respectively integrated with these pieces of adsorptive material and extending outwards from the edge faces of the pieces of adsorptive material (2a, 2b). In this example, a pair of mutually facing pieces of adsorbent body (1a, 1b) is used.

[0015]

Because the above-mentioned pieces of adsorptive material (2a, 2b) consist of sintered sheets of activated carbon fiber, they are characterized by being of adsorptive material that is essentially activated carbon, with practically no binders present therein. The above-mentioned carbon electrodes (3a, 3b) are composed of carbon-fiber yarn, which unravels into carbon filaments (4a, 4b) inside the pieces of adsorptive material (2a,

2b) and is intertwined with the activated carbon fiber and such. For this reason, the strength of bonding between the pieces of adsorptive material (2a, 2b) and the carbon electrodes (3a, 3b) is extremely high.

[0016]

Furthermore, spacers (5) have been formed in a grid-like fashion on the surface of one piece of adsorptive material (2a), and grid-like grooves (6) have been formed on the surface of the other piece of adsorptive material (2b) in such a manner that their location is different from the above-mentioned spacers (5). For this reason, by using the spacers (5), a pair of pieces of adsorptive material (2a, 2b) can be arranged in a noncontact state, with maze-like flow channels formed between the piece of adsorptive material (2a) and the piece of adsorptive material (2b).

[0017]

Such an adsorbent body (1) is placed inside a casing (not shown in the figure), provided with a supply port, through which gases, liquids, and other fluids to be treated are supplied, and an exhaust port, through which fluids treated using the above-mentioned pieces of adsorptive material (2a, 2b) are discharged.

[0018]

When such an adsorbent body (1a, 1b) is used, as the fluids to be treated flow through the passages between the above-mentioned pieces of adsorptive material (2a, 2b), they are subjected to germicidal treatment along with adsorption treatment. Namely, because an electric field is formed between the pieces of adsorptive material (2a, 2b) when voltage is applied to the above-mentioned carbon electrodes (3a, 3b), *E. coli,* other microorganisms contained in the fluid to be treated, and microorganisms adhered to the pieces of adsorptive material (2a, 2b) can be exterminated. In particular, electric conductivity is high because the adsorptive material (2a, 2b) is a sintered carbonaceous material. Also, the carbon electrodes (3a, 3b), superior in chemical resistance and corrosion resistance, are formed integrally with the pieces of adsorptive material (2a, 2b) and, moreover, are entwined with the activated carbon fiber. For this reason, the strength of bonding between the pieces of adsorptive material (2a, 2b) and the carbon electrodes (3a, 3b) is high, and the germicidal effects can be maintained for an extended period of time.

[0019]

Also, the components adsorbed from the fluids to be treated are removed from the above-mentioned pieces of adsorptive material (2a, 2b). In particular, because the adsorptive material (2a, 2b) is made of carbonaceous material in the form of sintered sheets, high adsorptive performance of the activated carbon fiber can be guaranteed. Furthermore, because the fluid to be treated

flows mainly through the above-mentioned flow channels, pressure drop is small. In addition, the components to be adsorbed from the fluids to be treated are diffused by osmosis inside the pieces of adsorptive material (2a, 2b), thereby undergoing efficient adsorption treatment. For this reason, the adsorbent body (1a, 1b) combines high adsorptive capacity with low pressure drop.

[0020]

Furthermore, because the adsorptive material (2a, 2b) is a carbonaceous material, its mechanical strength and shape retention properties are significant, while replacement and such of the above-mentioned adsorbent body (1a, 1b) are easy.

[0021]

In addition, carbon in arbitrary form, such as fibrous, powdered, and such, can be used as the activated carbon contained in the above-mentioned adsorptive material. In particular, when activated carbon fiber is employed, a high-strength sintered body is obtained by using a small amount of binder owing to structural characteristics, such as high strength in the direction of orientation of fibers and entanglement of fibers. As the activated carbon fiber, it is usually preferable to use activated carbon with a fiber diameter of about 2-30 μm and a fiber length of about 0.1-10 mm, which has micropores with a pore diameter of about 8-20 Å and a specific surface area of about 500-2500 m^2/g. From the standpoint of adsorption and desorption characteristics, finely divided activated carbon with an average particle diameter

of approximately 10-100 μm and a specific surface area of not less than 500 m^2/g is preferable as the powdered activated carbon.

[0022]

There are no particular limitations concerning the origin of the activated carbon, and, for instance, it may be derived, inter alia, from coal, petroleum, phenolic resins, polyacrylonitrile, cellulose, coconut shells, wood.

[0023]

The sintered body of activated carbon is produced by adding, as needed, not more than 20 parts by weight, and, preferably, about 2-20 parts by weight binder to 100 parts by weight activated carbon and mixing them together, followed by forming and sintering. When a sintered body of sufficient strength is obtained even when carrying out sintering using the activated carbon alone, there is no need to use the binder.

[0024]

Sinterable binders that integrate with the activated carbon through the sintering operation are particularly appropriate when using a binder. The sinterable binders are exemplified, for instance, by infusibilized carbon made up of unsintered carbon obtained by subjecting source pitch to infusibilization treatment; aramide resin, phenolic resin, epoxy resin, urea resin, and other thermosetting resins; infusibilized acrylic

resin, infusibilized polyvinyl alcohol resin, and other infusibilized heat-meltable resins. Binders capable of carbonization are preferable among these sinterable binders. These sinterable binders are different from heat-meltable binders, being characterized by an extremely low proportion of clogged pores in the activated carbon. Furthermore, when the sinterable binders are utilized in fibrous form (for example, when using unsintered carbon fiber obtained by spinning the source pitch and subjecting it to infusibilization treatment) the proportion of clogged pores in the activated carbon becomes even smaller. It is preferable to use binders with a filament diameter of about 5-100 μm and a length of about 0.1-5 mm.

[0025]

Up to 50 parts by weight of a reinforcing material per 100 parts by weight of the activated carbon may be added, as needed, to the activated carbon or to a mixture of an activated carbon and a binder. Such reinforcing materials are exemplified, inter alia, by hemp, paper pulp and other natural fibers, polyethylene, polypropylene and other heat-meltable fibers.

[0026]

In addition, the above-mentioned binders and reinforcing materials are carbonized and/or gasified in the sintering step, which will be described later.

[0027]

The above-mentioned adsorptive material does not need to be plate- or sheet-shaped as shown in the figure, and as long as it is a sintered body containing activated carbon, it may be curved, or of a hollow cylindrical, hollow polygonal shape, etc.

[0028]

The density of the adsorptive material should be within a range in which it does not adversely affect adsorptive capacity, strength and other characteristics, but it is preferable that at least the density of the portion integrated with the carbon electrodes should be not less than 0.4 g/cm^3, and especially, 0.4-1.0 g/cm^3, because this enhances the bonding strength. The average density of the adsorptive material is, for instance, not less than 0.4 g/cm^3, and, preferably, about 0.4-1.0 g/cm^3. An adsorptive material of such a high density not only has a high strength, but is also superior in adsorptive capacity, because it is composed mainly of activated carbon. In addition, the density of the adsorptive material on the side that is in contact with the fluid to be treated should be not more than 0.4 g/cm^3, for instance, 0.1-0.4 g/cm^3, because this promotes the osmosis and dispersion of the fluid to be treated.

[0029]

The thickness of the sheet adsorptive material made up of sintered sheets is, for instance, 0.05-5 mm, and preferably

0.2-1 mm. When the thickness of the adsorptive material exceeds 5 mm, in some cases, activated carbon contained inside is not efficiently utilized, because the adsorptive material has a high density.

[0030]

Also, there are no particular limitations concerning the type of carbon electrode, and, for instance, it may be an oblong piece of graphite film or such, but in order to enhance integration with the adsorptive material, it is preferable for it to contain carbon fiber. The electrode that contains carbon fiber contains, for instance, a yarn, cloth, or knitted fabric of carbon fiber, etc. A preferable electrode would be made of a material that possesses elasticity and does not rupture during forming, for instance, a yarn of carbon fiber, etc.

[0031]

In the example shown in the above-mentioned figure, the carbon fiber is unraveled into filaments which are then intertwined and integrated with the activated carbon fiber of the adsorptive material. To enhance integration with the adsorptive material, however, an electrode containing carbon fiber may be formed into a meandering or curved shape inside or in the surface layer portion of the adsorptive material. When the activated carbon of the adsorptive material includes activated carbon fiber, it is useful for the carbon electrodes to include carbon fiber, which can raise the degree of intertwinement of fiber. In addition, when a sinterable binder is used, the adsorptive

material and the electrodes are integrated, and for this reason the carbon electrodes may be bonded on the surface of the adsorptive material.

[0032]

Flow channels for the fluid to be treated should be formed between the two pieces of adsorptive material. The above-mentioned flow channels can be formed in various shapes. For instance, ridges and valleys may be formed on the opposing faces of both pieces of adsorptive material. Also, a flow channel may be formed by arranging the piece of adsorptive material with a gap in between. The adsorbent body is not limited to a pair of pieces of adsorptive material and may be composed of multiple pairs of pieces of adsorptive material.

[0033]

The gap between the pieces of adsorptive material consisting of sintered bodies can be selected appropriately in accordance with the conditions of use of the adsorbent body. With account taken of the magnitude of pressure drop and the length of the adsorbent body, it is preferable that the gap between the pieces of adsorbent material should be 0.05-10 mm. When the gap between the pieces of adsorbent material is less than 0.05 mm, pressure drop increases, and when it exceeds 10 mm, the material to be adsorbed tends to pass through.

[0034]

The adsorbent body of the present invention is produced by carrying out a forming step, wherein at least activated carbon is subjected to forming, and a sintering step, wherein the resultant formed article is sintered.

[0035]

The above-mentioned forming step is not limited to activated carbon alone, and mixtures of activated carbon with sinterable binders, or mixtures further comprising reinforcing materials, can be used as well. Preferably, mixtures comprising activated carbon and sinterable binders are used.

[0036]

In the forming step, a part of the above-mentioned carbon electrodes is placed in the forming mold together with activated carbon and the above-mentioned mixtures, and is subjected at least to press forming. During forming, it is preferable to carry out press forming under heating. In the forming step, based on this, activated carbon and carbon electrodes are compressed and integrated in one body in a formed article. If in the forming step, the end portions of the carbon-fiber yarn, as described above, are unraveled into filaments and the carbon electrodes are placed in the forming mold in a meandering or curved shape, the integration between activated carbon and the carbon electrodes is further enhanced.

[0037]

Forming can be carried out in accordance with the density of the adsorptive material, for instance, at a pressure of 5-1,000 kgf/cm^2, and preferably at about 100-800 kgf/cm^2. When the pressure of press forming is less than 5 kgf/cm^2, there is a tendency to produce adsorptive material of low strength and low density, and when it exceeds 1000 kgf/cm^2, pores in the activated carbon are destroyed, and there is the danger of reducing the adsorptive performance of the adsorptive material.

[0038]

When fibrous materials are used as the activated carbon, a preform of low density may be prefabricated by a dry or wet technique and then subjected to sintering.

[0039]

In the case of the wet technique, activated carbon alone, a mixture comprising activated carbon and a sinterable binder, or a mixture further comprising a reinforcing material is dispersed in water and mechanically agitated to produce a water-base slurry, followed by pouring the water-base slurry into a forming mold with a suction hole to obtain a preform by suction. During suction forming, a part of the carbon electrodes is placed inside the forming mold and is subjected to suction forming together with the activated carbon. The preform can be obtained by papermaking techniques, wherein paper is prepared by including a part of the carbon electrodes. After drying the resultant

preform, it is placed in a mold, formed, and supplied to the sintering step. In the case of the dry process, a preform in the form of nonwoven cloth or such prefabricated by the dry process may be placed in a mold, and sintered under the same conditions as those described above. A part of the carbon electrodes may be mechanically intertwined and bonded to the preform in the dry process, and then supplied to the forming step and sintering step, or may be placed in the mold together with the preform for forming and sintering.

[0040]

When such preforms are used, handling is made easier, and density variation can be prevented. In particular, when preforms fabricated by the wet technique are used, the variation in metsuke is small, and variation in the density of the sintered bodies is reduced as well.

[0041]

As is evident from the above, in the forming step, in the process of suction forming a slurry comprising activated carbon fiber and a binder using a suction forming mold, it is preferable to carry out suction forming by placing carbon-fiber yarn in the suction forming mold. Also, under the papermaking technique, it is preferable to make paper from slurry together with a part of carbon-fiber yarn.

[0042]

The formed article obtained in the forming step is supplied to the sintering step, during which it is sintered, for instance, at a temperature of 500-1500°C, and, preferably, 800-1300°C. When the temperature of sintering is less than 500°C, sintering is incomplete, which tends to result in low-strength, low-density adsorptive material. When the temperature of sintering exceeds 1500°C, the pores of the activated carbon are liable to be clogged by the sinterable binder, and there the adsorptive capacity of the adsorptive material tends to decrease. The above-mentioned sintering firmly integrates the adsorptive material in one body with the carbon electrodes. Also, when the formed articles comprise a sinterable binder, the strength of bonding between the adsorptive material and carbon electrodes can be made even higher. In the course of sintering, the binder and reinforcing materials are carbonized and/or gasified. For this reason, the resultant adsorbent body is of high density, high mechanical strength, and high activated carbon content. Also, because the adsorbent body is of carbonaceous material, it has a high thermal resistance, a high resistance to chemicals, and is superior in electrical conductivity. Furthermore, because a compression-molded formed article is subjected to sintering, the dimensional accuracy of the resultant adsorbent body is also high.

[0043]

The sintering can be carried out in an atmosphere of an inert gas, such as nitrogen gas, helium gas, and argon gas, or in

vacuo. The sintering time can be appropriately selected depending on the type of the activated carbon used, the shape of the formed article, the type and amount of the sinterable binder, etc., but usually, it is about 5 sec to 30 min.

[0044]

Effect of the invention

The following effects are produced by using the adsorbent body of the present invention.

[0045]

(1) Because the adsorbent body is formed out of sintered bodies of high density, the clogging of pores in the activated carbon can be conspicuously suppressed, and its electrical conductivity is high. For this reason, the adsorbent body, in which an adsorptive material is integrated in one body with carbon electrodes, along with possessing a high adsorptive capacity, exhibits high germicidal effects due to the voltage applied to the above-mentioned electrodes.

[0046]

(2) When the adsorbent body is built by forming flow channels between several pieces of adsorptive material, fluids to be treated can be treated with little pressure drop.

[0047]

(3) Because of the significant strength of bonding between the adsorptive material and the carbon electrodes, the above-mentioned adsorption treatment and germicidal treatment can be smoothly conducted during an extended period of time.

[0048]

(4) The adsorptive material formed out of sintered bodies is superior in mechanical strength, heat resistance, and resistance to chemicals. Therefore, the adsorbent body, along with superior ease of handling, has a high adsorptive capacity under harsh conditions.

[0049]

If the process of the present invention is used, then, due to comprising the forming step and sintering step, pieces of adsorptive material can be produced which, along with possessing the above described superior characteristics, have a high dimensional accuracy.

[0050]

Application example

Hereafter, the details of the present invention are explained with the application example.

[0051]

Application example

98 parts by weight pitch-based activated carbon fiber with a specific surface area of 1500 m^2/g (A-15 from Adouru [transliteration] (K.K.)) and, as a binder, 2 parts by weight of an acrylic resin binder were dispersed in water, and a uniform slurry was obtained by reducing the length of the carbon fiber to within 5 mm.

[0052]

Subsequently, part of carbon-fiber yarn was placed in a flat mold having a plurality of suction holes in the base and the above-mentioned slurry was poured in and aspirated, obtaining a flat wet molded sheet (100 mm x 100 mm) with a metsuke of about 360 g/m^2. The wet molded sheet was kept under a pressure of 50 kg/cm^2 and at a temperature of 930°C for 20 sec to obtain a flat plate-shaped adsorbent body with thickness of 0.5 mm and a bulk density of 0.6 g/cm^3, such as the one shown in (1a) of Figure 1.

[0053]

Also, in the same manner, an adsorbent body with grooves, such as the one shown in (1b) of Figure 1, was obtained by using a flat plate-shaped forming mold and a forming mold provided with grid-like protrusions. The gaps between the grooves were 5 mm, and the groove depth was about 0.1 mm. Spacers with a thickness

of about 0.1 mm were adhered to the flat plate-shaped adsorbent body in the manner shown in Figure 1.

[0054]

A pair of adsorbent bodies was obtained from the above-mentioned adsorbent bodies (1a, 1b). The resultant adsorbent was capable of treating fluids with low pressure drop, the contact electrical resistance of the adsorbent body and the carbon electrodes was small, and the strength of bonding therebetween was high.

Brief description of the figures

Figure 1 is an exploded oblique view showing an adsorbent body which is an application example of the present invention.

Explanation of symbols

1a,1b	Adsorbent bodies
2a,2b	Pieces of adsorptive material
3a,3b	Carbon electrodes
4a,4b	Carbon filaments
5	Spacers
6	Grooves

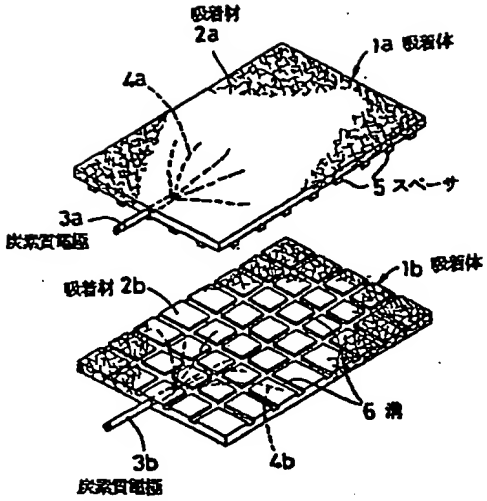


Figure 1

Key: 1a Adsorbent body
1b Adsorbent body
2a Piece of adsorptive material
2b Piece of adsorptive material
3a Carbon electrode
3b Carbon electrode
5 Spacers
6 Grooves